Journal of Nanoscience and Nanotechnology 2017 vol.17 N8, pages 5310-5317

Gold nanoparticles formation in solid polyelectrolyte: The catalytic effect of halloysite nanotubes

Battistoni S., Dimonte A., Ubaldi E., Lvov Y., Erokhin V.
Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

© Copyright 2017 American Scientific Publishers All rights reserved. Clay nanotubes are kaolinite rolled-up sheets, discovered few years ago and, up to now, mainly exploited as carriers for drug delivery. Although available in tons, biocompatible and nontoxic, they remain sophisticated and novel natural nanomaterials. The possibility to mix them with polymers, both polar and not, opens many functional biocomposites developments. In this paper we report a novel property of this interesting material: a catalytic effect of gold dissolution when added to a polyethylene oxide gel doped with a lithium salt. We proved that the resulting material, placed between two gold electrodes, has anisotropic features and, more interestingly, over a certain voltage threshold, can speed up the formation of gold nanoparticles coming out from the gold electrodes. Fitting the electrical measurements we also have found that gold nanoparticles contribute to the total current flow and this effect can be described by adding an intercept in the function of the current trend.

http://dx.doi.org/10.1166/jnn.2017.13802

Keywords

Anisotropic, Catalytic effect, Gold nanoparticles, Halloysite clay nanotubes

References

[1] I. Borukhov, D. Andelman, and H. Orland, EPL (Europhysics Letters) 32, 499 (1995).
[2] A. V. Dobrynin, A. Deshkovski, and M. Rubinstein, Macromolecules 34, 3421 (2001).
[3] I. W. Hamley, Introduction to Soft Matter: Synthetic and Biological Selfassembling Materials, John Wiley & Sons, Hoboken, New Jersey (2013).
[4] J. Borges and J. F. Mano, Chemical Reviews 114, 8883 (2014).
[5] P. Dubin, J. Bock, R. Davis, D. N. Schulz, and C. Thies, Macromolecular Complexes in Chemistry and Biology, Science and Business Media, Springer, New York City (2012).
[6] R. R. Costa and J. F. Mano, Chem. Soc. Rev. 43, 3453 (2014).
[7] A. S. Sergeeva, D. A. Gorin, and D. V. Volodkin, BioNanoScience 4, 1 (2014).
[8] J. Almodóvar, T. Crouzier, Š. Selimović, T. Boudou, A. Khademhosseini, and C. Picart, Lab on a Chip 13, 1562 (2013).
[9] C. S. Karamitros, A. M. Yashchenok, H. MoÌL'hwald, A. G. Skirtach, and M. Konrad, Biomacromolecules 14, 4398 (2013).
[10] D. Volodkin and R. von Klitzing, Curr. Opin. Colloid Interface Sci. 19, 25 (2014).
[11] A. Poghossian, M. Weil, A. Cherstvy, and M. J. Schöning, Analytical and Bioanalytical Chemistry 405, 6425 (2013).

[12] N. Joseph, P. Ahmadiannamini, R. Hoogenboom, and I. F. Vankelecom, Polymer Chemistry 5, 1817 (2014).

[13] K. Tang and N. A. Besseling, Soft Matter. 12, 1032 (2016).

[14] R.-Q. Song, H. CÃulfen, A.-W. Xu, J. Hartmann, and M. Antonietti, ACS Nano 3, 1966 (2009).

[15] J. Dai and M. L. Bruening, Nano Letters 2, 497 (2002).

[16] X. Zan and Z. Su, Langmuir 25, 12355 (2009).

[17] J. Wei, L. Wang, X. Zhang, X. Ma, H. Wang, and Z. Su, Langmuir 29, 11413 (2013).

[18] R. Teixeira, P. M. R. Paulo, A. S. Viana, and S. M. B. Costa, The Journal of Physical Chemistry C 115, 24674 (2011).

[19] Y. Lvov, A. Aerov, and R. Fakhrullin, Advances in Colloid and Interface Science 207, 189 (2014).

[20] Y. Lvov and E. Abdullayev, Progress in Polymer Science 38, 1690 (2013).

[21] K. Banu and T. Shimura, New Journal of Chemistry 35, 1031 (2011).

[22] G. Baldi, S. Battistoni, G. Attolini, M. Bosi, C. Collini, S. Iannotta, L. Lorenzelli, R. Mosca, J. Ponraj, and R. Verucchi, Semiconductor Science and Technology 29, 104009 (2014).

[23] T. Berzina, A. Smerieri, M. Bernabï, A. Pucci, G. Ruggeri, V. Erokhin, and M. P. Fontana, J. Appl. Phys. 105 (2009).

[24] S. Cherevko, A. A. Topalov, A. R. Zeradjanin, I. Katsounaros, and K. J. Mayrhofer, RSC Advances 3, 16516 (2013).

[25] K. Ogura, S. Haruyama, and K. Nagasaki, Journal of The Electrochemical Society 118, 531 (1971).

[26] T. B. Jones and T. B. Jones, Electromechanics of Particles, Cambridge University Press, Pennington, New Jersey (2005).

[27] R. Kretschmer and W. Fritzsche, Langmuir 20, 11797 (2004).

[28] A. Yu, X. Zhang, H. Zhang, D. Han, and A. R. Knight, Electrochimica Acta 56, 9015 (2011).

[29] S. Link and M. A. El-Sayed, The Journal of Physical Chemistry B 103, 4212 (1999).

[30] S. Link, Z. L. Wang, and M. El-Sayed, The Journal of Physical Chemistry B 103, 3529 (1999).

[31] S. Battistoni, E. Ubaldi, and A. Dimonte, BioNanoScience 5, 185 (2015).

[32] Y. Bar-Cohen, X. Bao, S. Sherrit, and S.-S. Lih, Characterization of the electromechanical properties of ionomeric polymer-metal composite (ipmc), SPIE's 9th Annual International Symposium on Smart Structures and Materials, International Society for Optics and Photonics, San Diego, CA (2002), pp. 286-293.

[33] A. Aharony and D. Stauffer, Introduction to Percolation Theory, Taylor and Francis, Abingdon-on-Thames, Oxfordshire United Kingdom (2003).